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Mobility modelling for simulation of spatial spread of infectious diseases

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The COVID-19 pandemic has highlighted the importance of public health policies and crisis management. The spread of diseases is a complex phenomenon with many time-dependent variables, which hampers an accurate prediction of epidemic evolution. Models of epidemic spread play an important role in guiding in designing public health policies, enabling hypothetical scenarios simulation and rapid analyses of ongoing epidemics.

Over the last century disease spread models evolved from deterministic compartmental models into complex metapopulation and agent-based simulations. Today's solutions consider many factors, not limiting to the disease itself but also simulating socio-demographic structure and population flows. In the era of globalisation, human mobility became the major factor of rapid disease spread. Although current models consider international and regional travels, used mobility models are simplistic. This limits the accuracy and spatio-temporal resolution of these simulations, providing daily cases updates aggregated to large regions.

We propose an agent-based mobility model, offering a simulation of hourly temporal resolution depicting mobility with less than a few hundreds of meters spatial precision. Agent-based models allow each simulation agent to assign different characteristics, e.g. susceptibility to infection, mobility behaviour.

We integrate our mobility model with disease spread simulation, using an agent's interaction to detect virus transmission. In every time step of the model, the interaction between the agents, their current state and localisation of interaction are used to determine the probability of infection. Social interactions in the context of the spread of the disease are a fundamental element influencing the temporal and spatial extent of the disease. An essential aspect of our model is the integration of the simulation environment with the points-of-interests (POIs), which represent the destination of the majority of non-home-work related activities. We validate the accuracy of mobility replication and present hypothetical scenarios of disease spread in one of the large European cities, presenting capabilities of our solution.